Integrated Science Instrument Module

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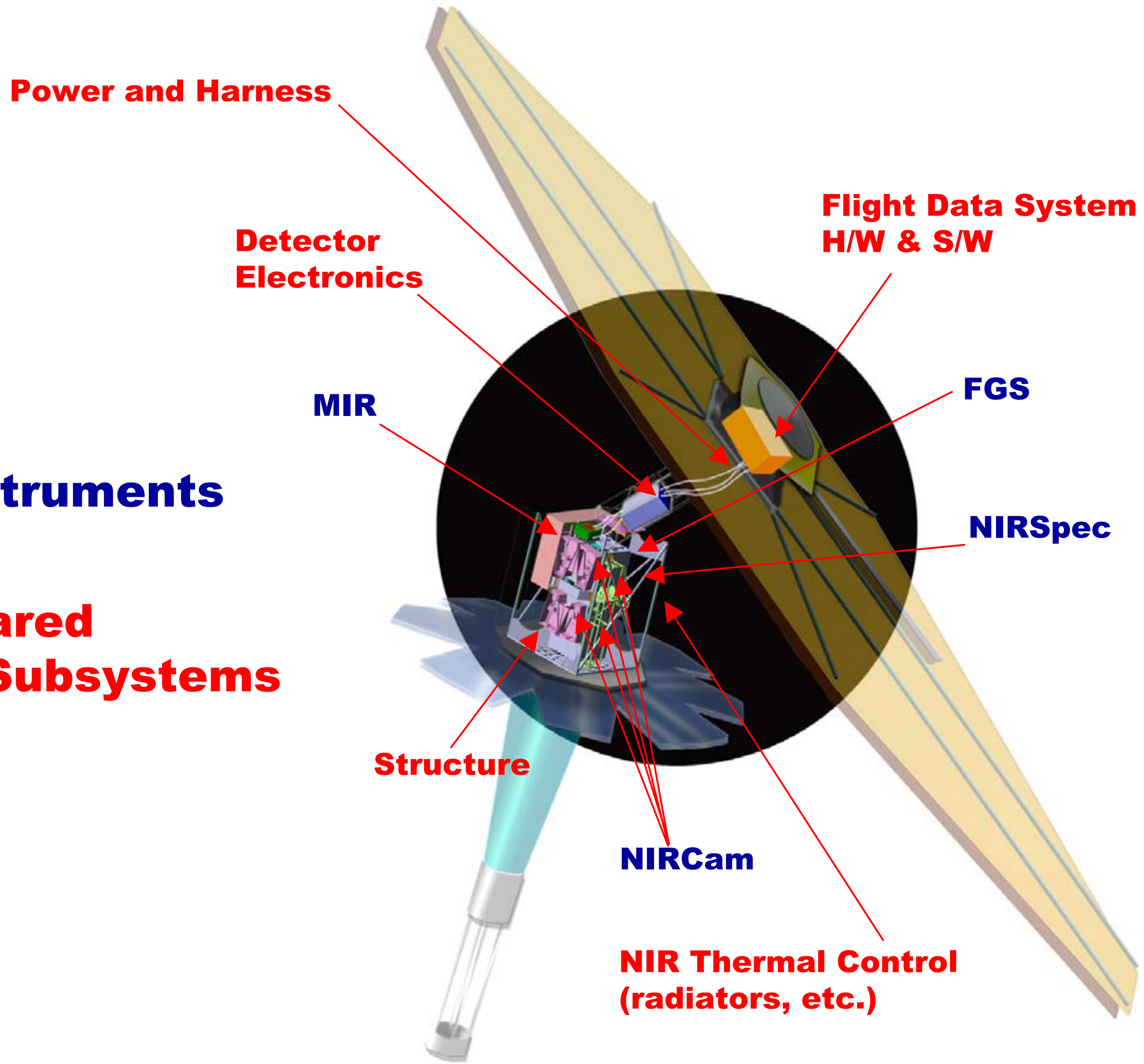
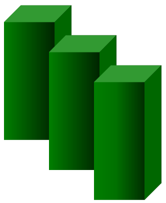
23 September 2002

ISIM is the Payload of JWST

Instruments

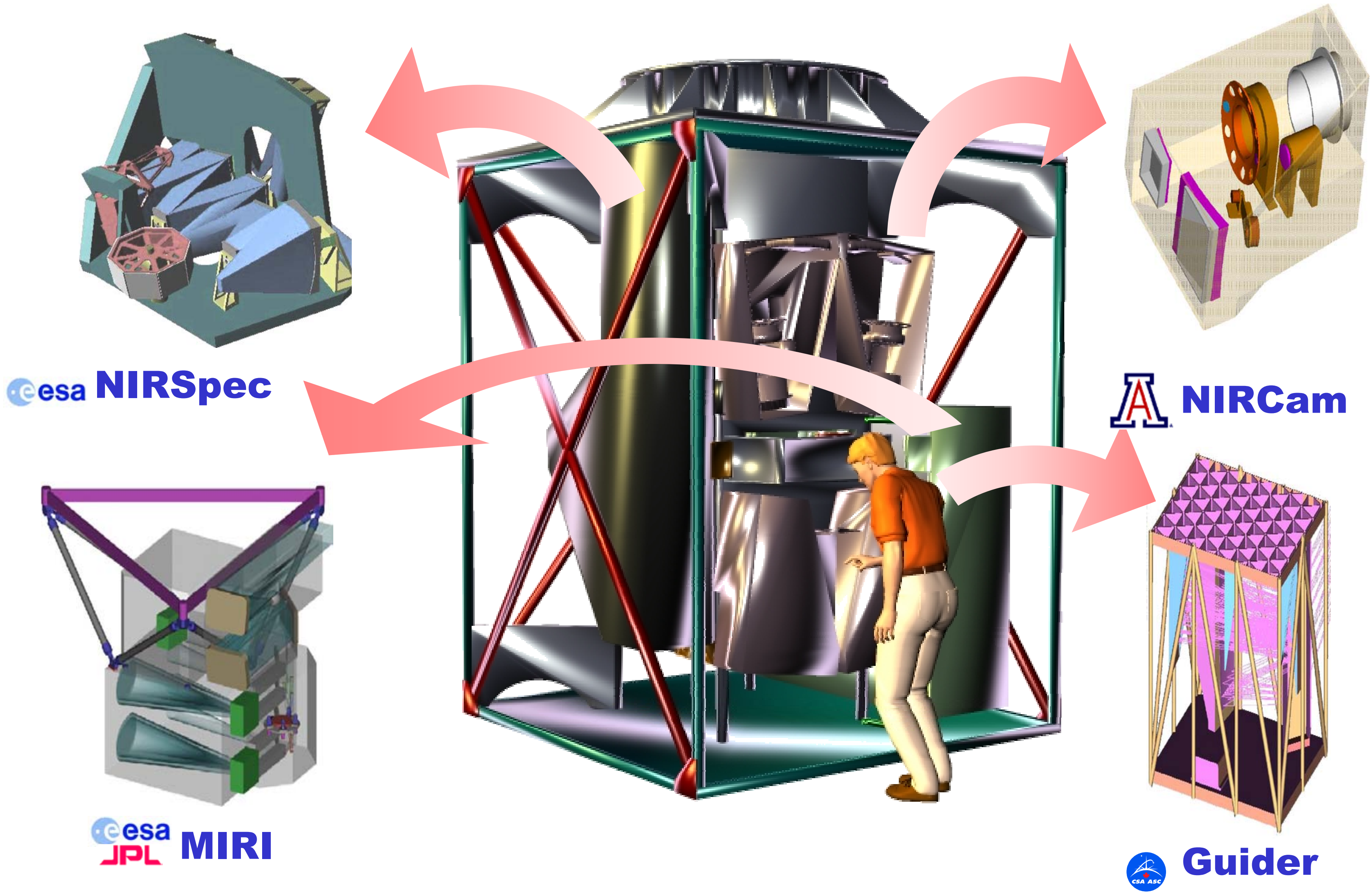
Shared Subsystems





Shared system GSE for prime and each SI

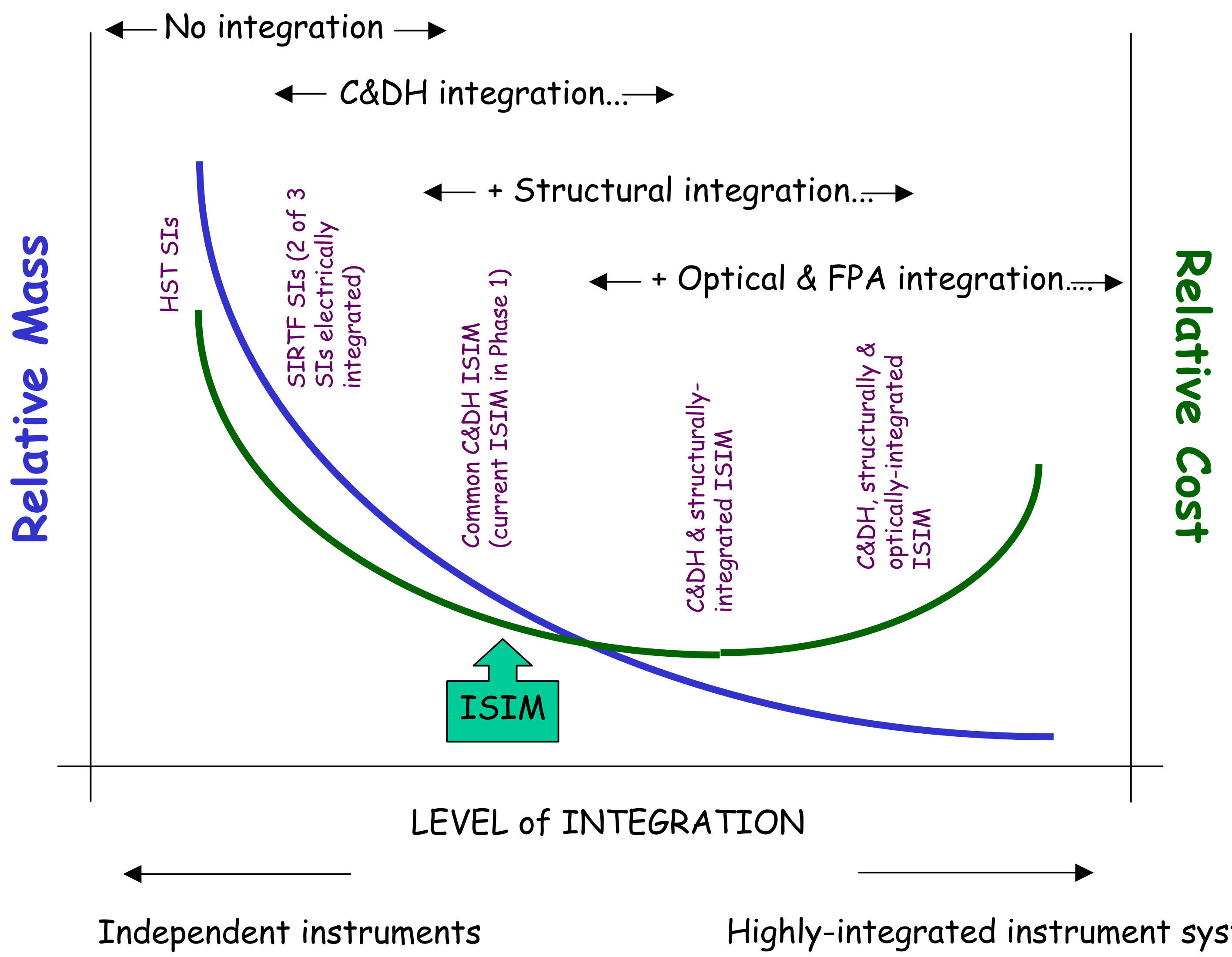
ISIM Cryogenic Portion



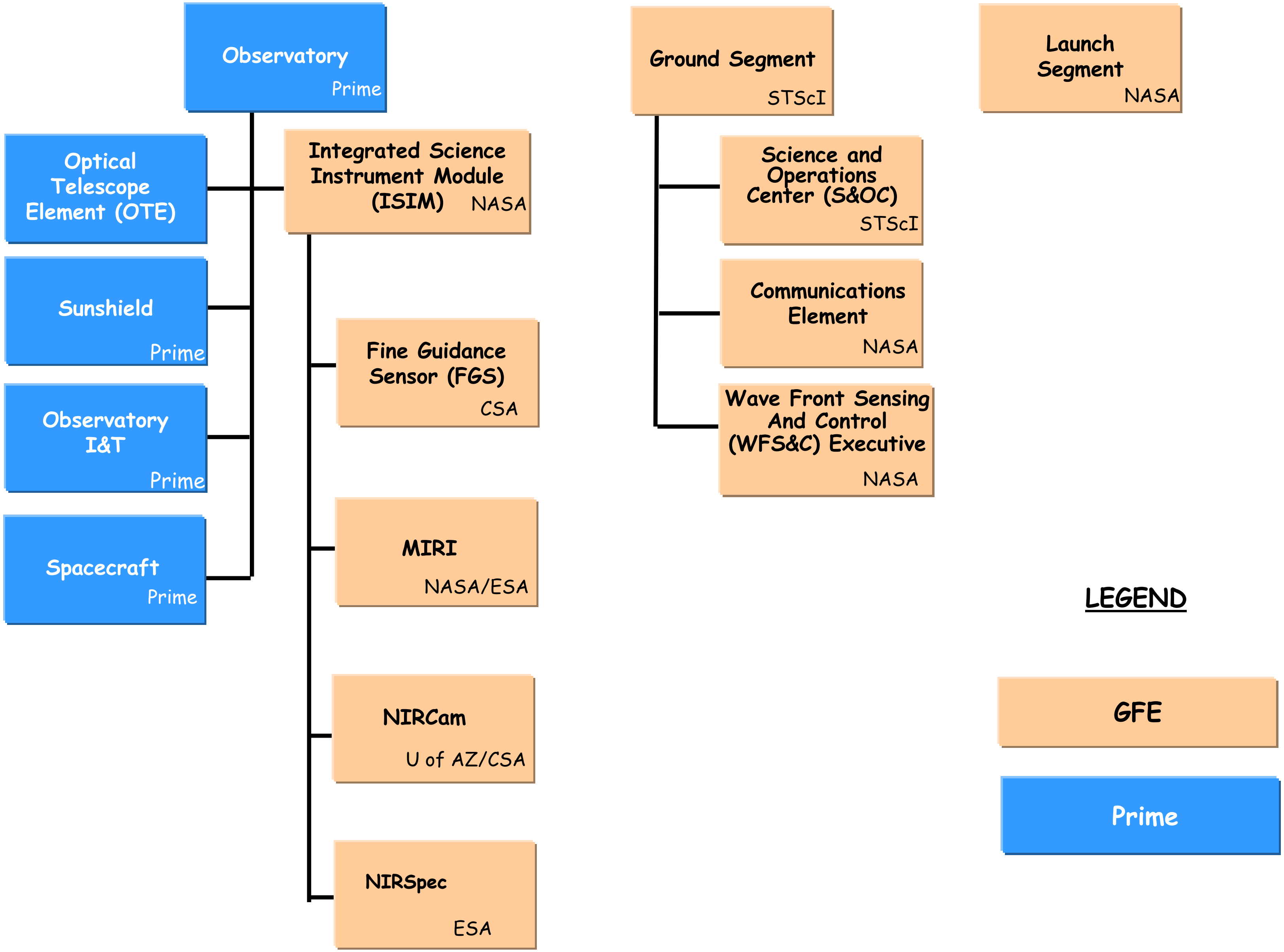
An *Integrated* SI Module Architecture Developed to Reduce Life Cycle Cost

- **Key life cycle cost (LCC) drivers include NRE, mass, I&T, and operations**
- **Flight cryogenic application provides unique challenges with respect to HST**
  - Tight systems integration yields reduced NRE costs and system mass
  - Modular implementation and incremental testing yields reduced I&T costs (particularly for cryo-applications)
- **Best value trade from phase A studies:**
  - Limited systems integration implemented by consolidating components with common functions into common systems that are shared by all science instruments
  - Unique instrument systems and shared systems implemented in modular fashion
- **Instrument system LCC is reduced ~30% by consolidating the instrument C&DH, detector electronics, and thermal management functions compared to a fully independent SI approach**
  - High quality systems engineering and SI customer (PI & SWG) interaction are key to successful implementation of this approach

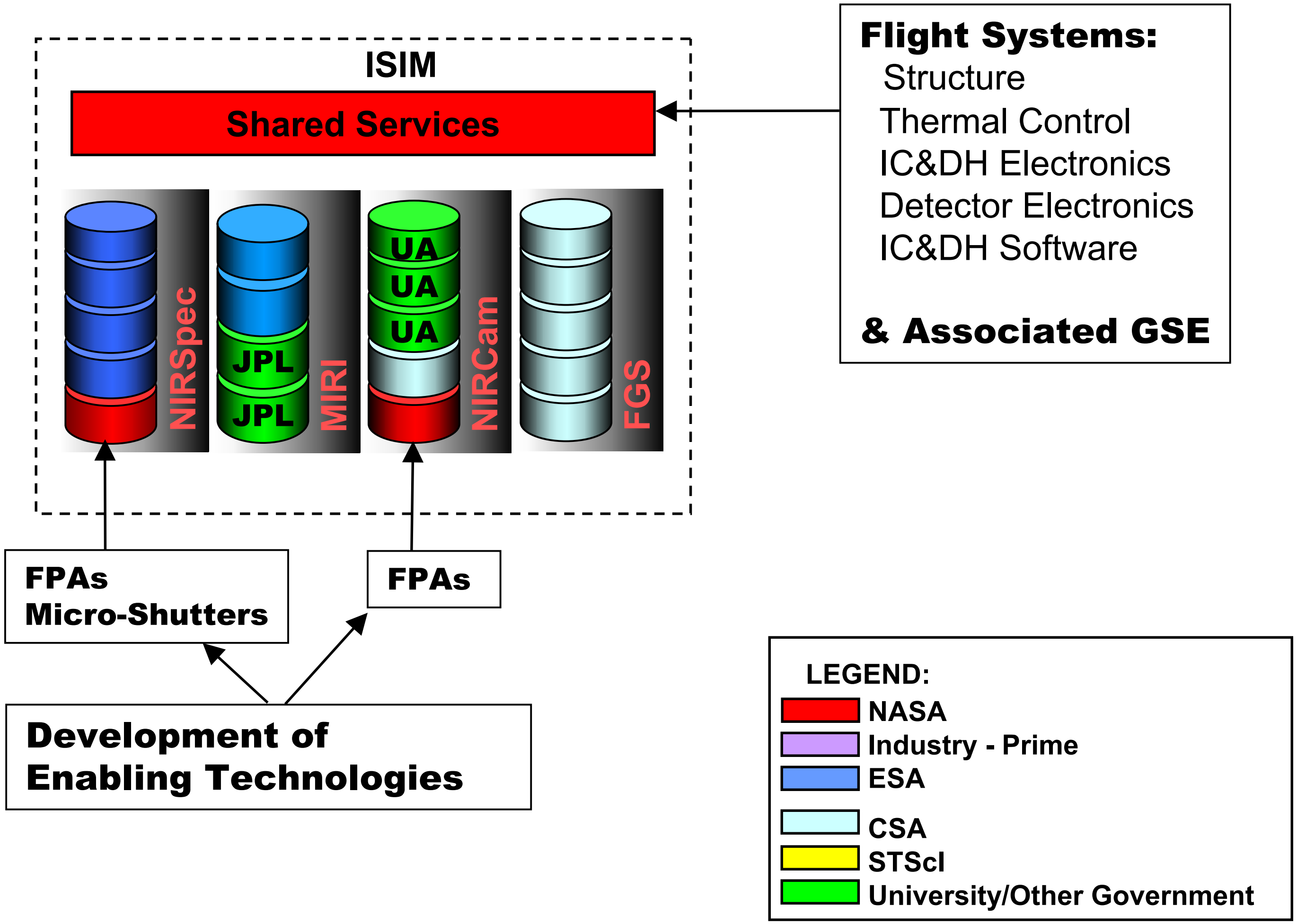
ISIM Mass and Cost vs. Integration



JWST Team Relationships



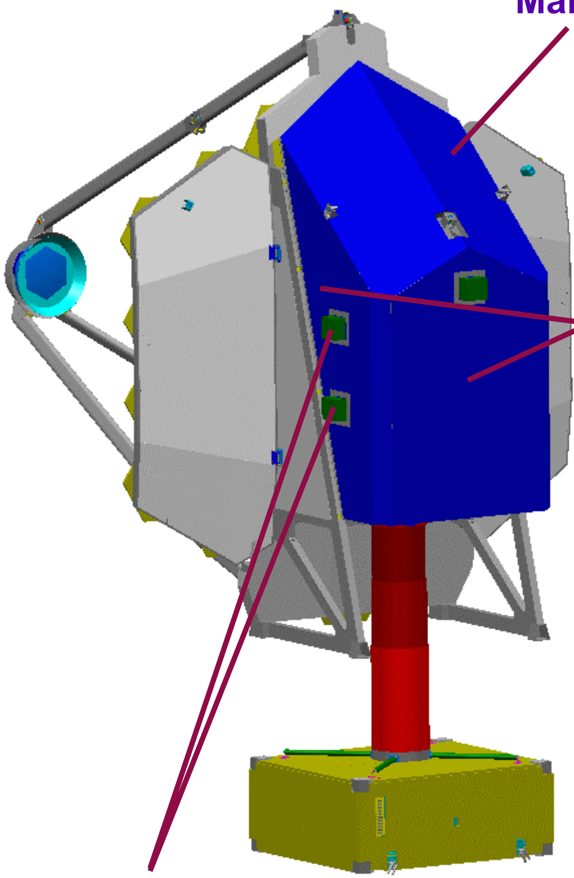
ISIM Team Relationships



ISIM Structure

- **Supporting structure that couples the NIRCam, NIRSpec, MIRI, FGS, Cryostat, SI pick-off mirrors, cold electronics and thermal radiators, heat straps, and electrical harness to the OTE**
- **Status:**
  - **Current designs for all four instrument systems can be accommodated within the TRW ISIM control volume and mass allocation**
    - NIRCam, NIRSpec, MIRI w/ 10 year cryostat, FGS
  - Baseline instrument support structure has been designed and analyzed
  - Instrument packaging approach developed through face to face concurrent engineering meetings with MIRI, NIRSPEC, and FGS teams
    - First of many such concurrent design interactions
  - Performed structural materials study. Selected M55J GrEp system as baseline for ISIM Structure.
  - Development of structure verification plan developed to appropriate level
    - Instrument alignment stability

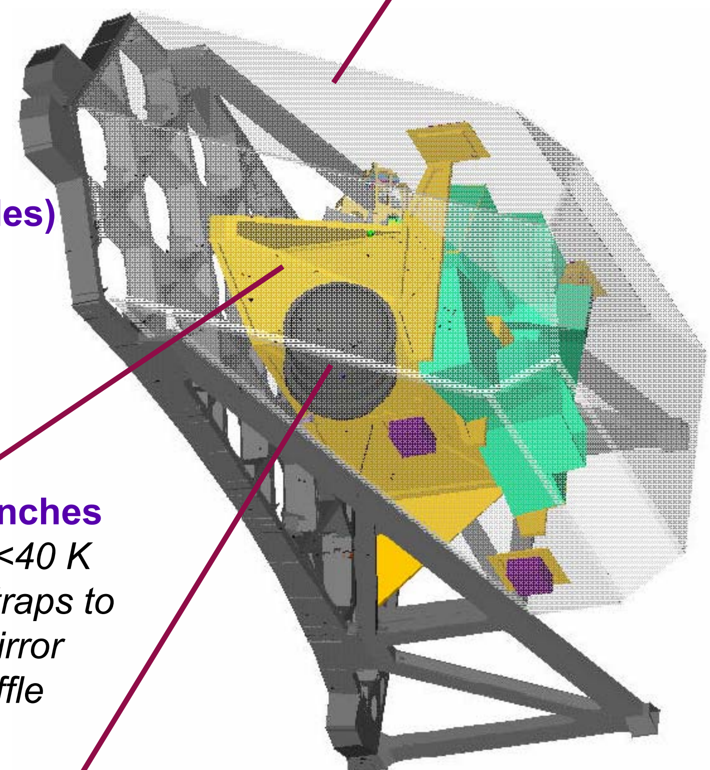
Phase 1 ISIM Thermal Control Concept



Main Radiator, ~ 9m²
cools near-IR FPAs to < 30 K via heat strap connections

Parasitic Radiators (4 sides)
rejects parasitic heat leaking from 290 K focal plane electronics

290 K FPEs (6 total)
mounted to enclosure via multi-stage radiator system (location conceptual only)



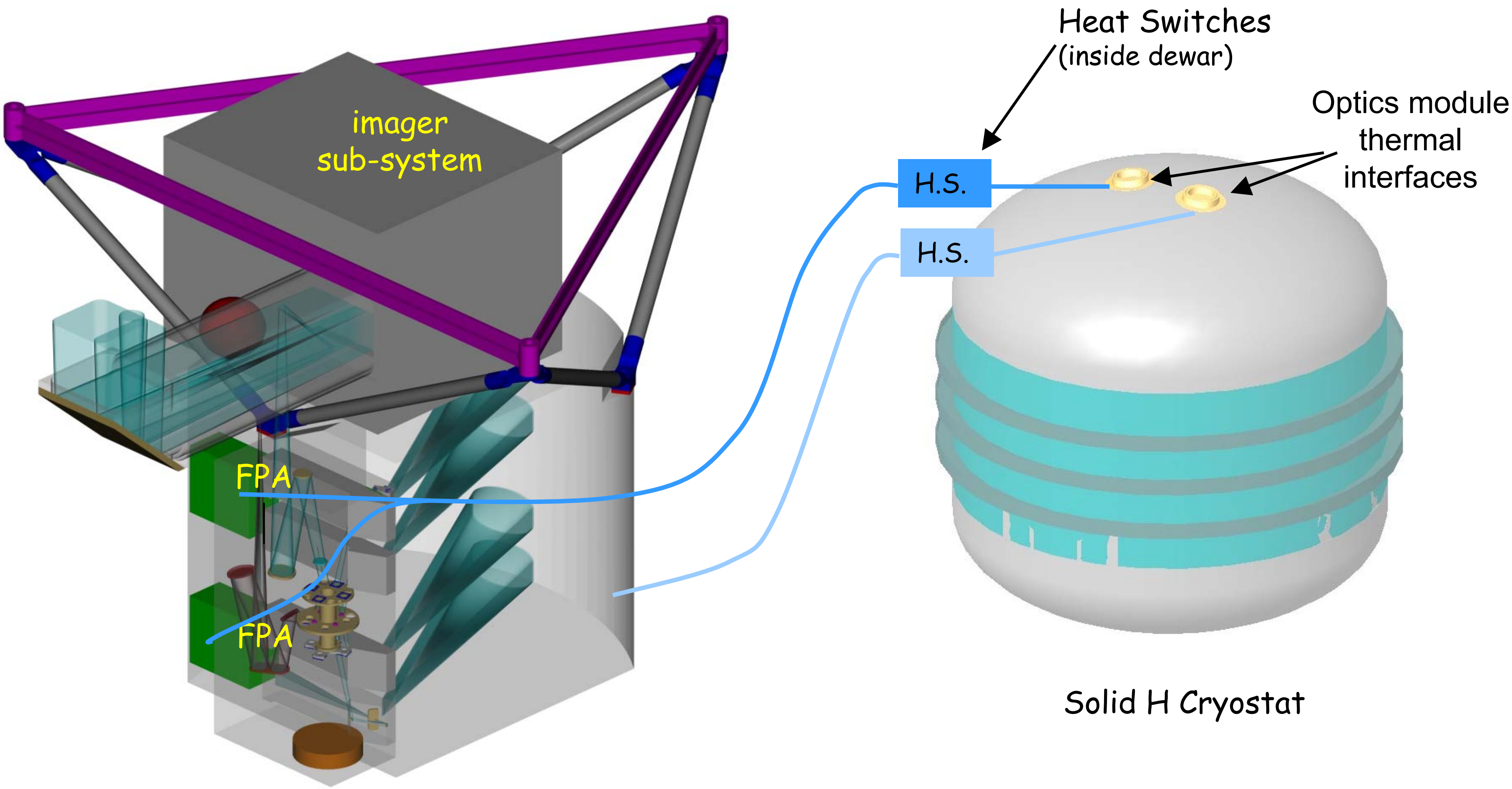
ISIM Thermal Enclosure/Radiator System

ISIM optical benches
cooled to <40 K via heat straps to primary mirror central baffle

MIRI SH_2 Cryostat
cools optics and FPA to < 7 K (location conceptual only)

MIRI Requires Active Cooling

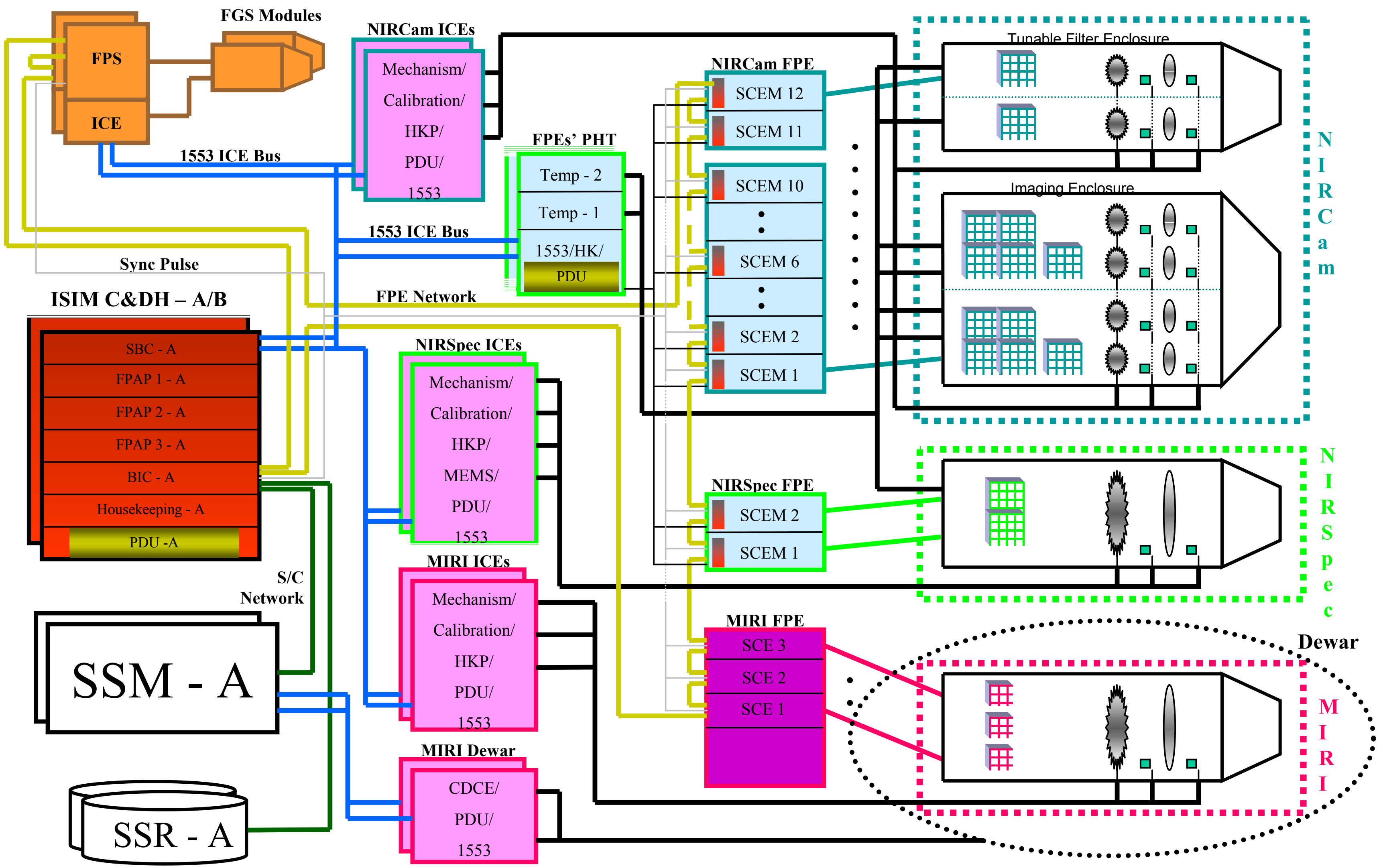
Baseline: Warm launch with solid hydrogen cryostat
Optics module ~7 K isothermal, 6.9 K detectors



MIRI Optics Module

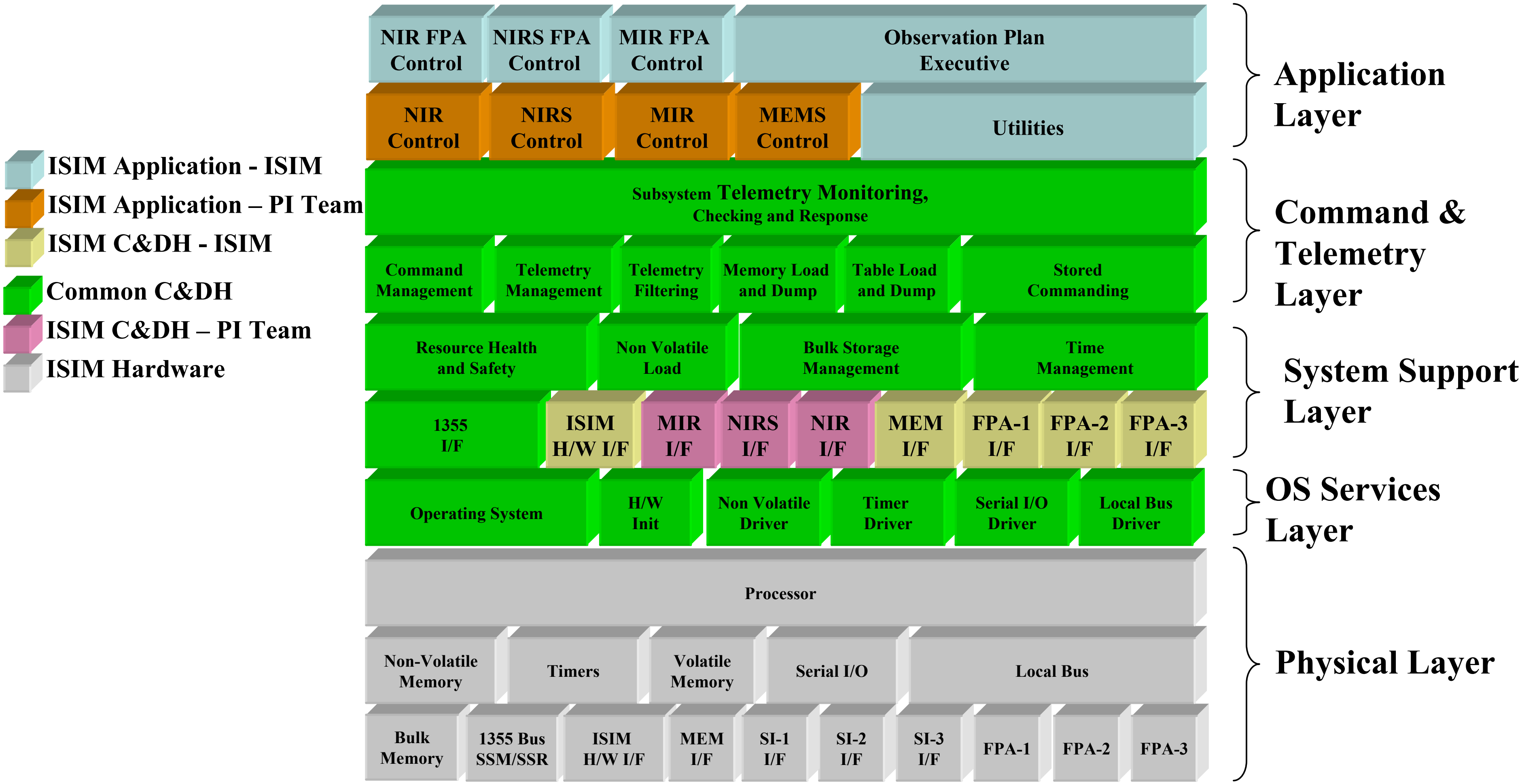
Solid H Cryostat

ISIM Electronics Designed to Support Detector Noise Goals, Minimize LCC, and Provide Clean SI Interface



CSA provided H/W	SIs' provided H/W	Code 561 provided H/W	Code 564 provided H/W	Code 563 Provided H/W	JPL Provided H/W

FSW Designed for Low LCC and Clean SI Interface



- Common command and telemetry interface to ground
- Simplified I&T
- Reduced NRE cost

ISIM / SI Team Interface

- **Close knit teaming relationship between ISIM and instrument PIs is key to success of integrated (shared services) approach**
- **Science instrument PIs are the customers for ISIM supplied shared services**
  - Instrument PIs in design review/approval chain
  - Instrument teams involved in engineering design formulation
    - E.g., detector and C&DH electronics
- **Our approach to instrument interface definition involves:**
  - Frequent in-depth interaction with SI teams
    - Concurrent engineering when needed
  - Design for ease of I&T
  - Clear science requirements flow-down
    - Science requirements defined/refined by SWG and SI teams

ISIM Technology Development

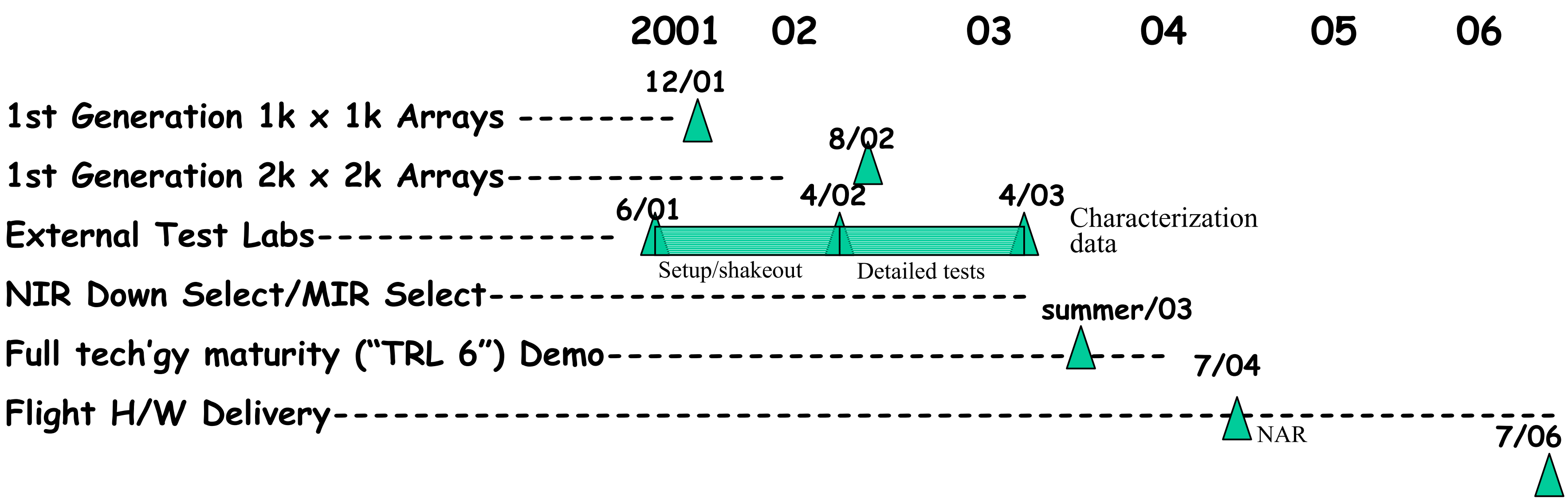
- **Detectors**
  - Near-Infrared (0.6 – 5 μm)
    - NIRCam, NIRSpec
  - Mid-Infrared (5 –28 μm)
    - MIRI
- **MEMS Micro-Shutters**
  - NIRSpec aperture control

Detector Development Program

- **Objective:**
  - Demonstrate large-format, low-noise arrays which satisfy JWST requirements and approach JWST goals
  - Establish technologies, designs, and processes so that detector vendors can proceed directly into a flight hardware build phase upon selection
- **In place contracts resulting from free and open competitive solicitations:**
  - Near IR (0.6 - 5 μm): improve sensitivity, optimize manufacturing processes, & develop packaging concepts.
    - Winners: InSb (Raytheon w/ U. Rochester) & HgCdTe (Rockwell w/ U. Hawaii)
  - Mid IR (5 - 28 μm): improve sensitivity & cryo readouts
    - Winner: Si:As (Raytheon)
  - External labs to fully characterize above technology products
    - Winners: Near-IR: U. Hawaii, U. Rochester, STScI, Mid-IR: ARC
- **Flight focal plane vendors: Selection June 03**

Development Status & Schedule

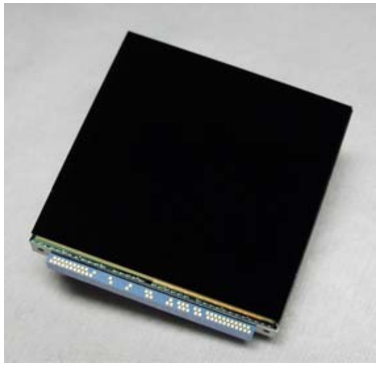
- Promising, focused array development progress from qualified competitors (NIR & MIR arrays) '98 - '03. Prototype SCAs and readouts under test. Key NIR focal plane implementation technologies (packaging & manufacturing) also being developed.
- Strong independent test lab network established.
- On track for FY03 down select, FY04 NAR, & eventual flight hardware deliveries.



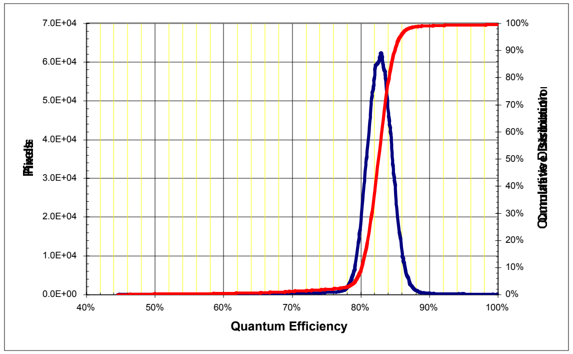
Tech Development Status: HgCdTe

Rockwell Scientific Company (RSC), w/ U. Hawaii (D. Hall)

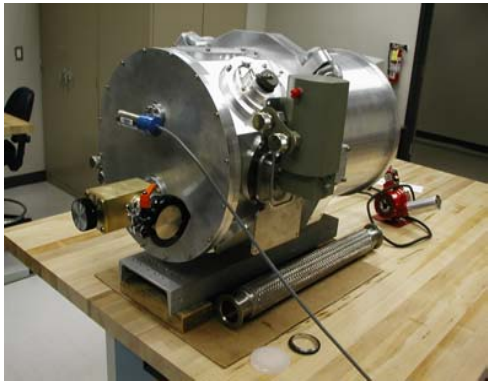
- **Hybrids produced and under test at RSC, UH, STScI, & ARC**
  - 1 k x 1 k **HAWAII-1RG** hybrids: 37 K UH data show ~10 e- CDS (Fowler 1) read noise, ~0.005 e-/s dark current, ~80% QE (RSC), with successful removal of CdZnTe substrate (opens visible response). Mux successfully rad-tested.
  - 2 k x 2 k **HAWAII-2RG** hybrids: 4 produced to date; UH data forthcoming. Yield of H-2RG readouts was 64% (sci grade). Expect same sensitivity as H-1RG. 1 H-2RG bare mux in test at STScI.
  - Pathfinder AR coat successfully applied. Packages for 4 k x 4 k in fab.
  - RSC ASIC chip (clock & bias generation adjacent to the focal plane, plus cold 16-bit A/D conversion) in final layout stages. Should have parts in ~6 weeks.



2 k x 2 k SCA



H-1RG QE plot (83% avg at K)

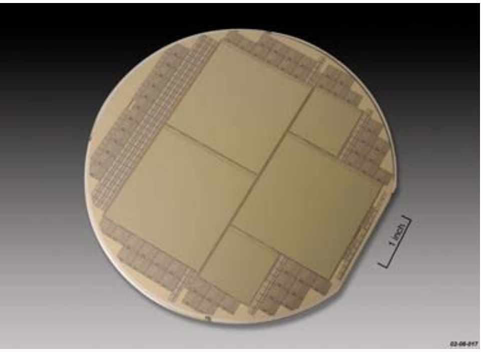


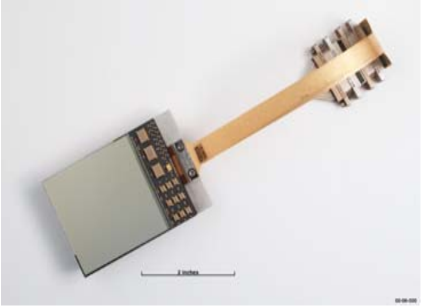
UH ULB Test Chamber

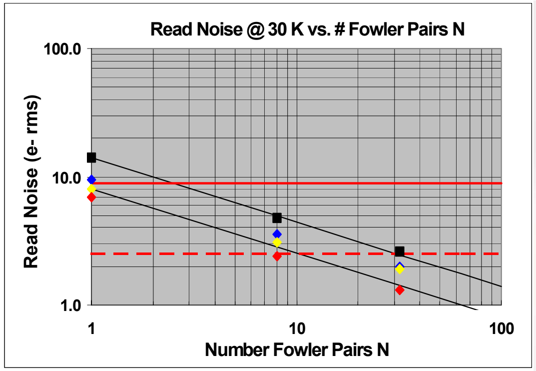
Tech Development Status: InSb

Raytheon IR Operations w/ U. Rochester (Forrest, Pipher)

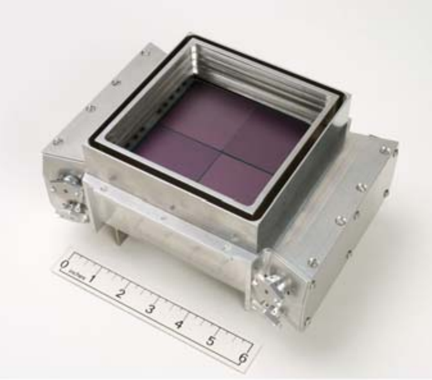
- **Hybrids produced & under test at RIO & UR**
  - 1 k x 1 k InSb arrays on **SB-226** & **-291** muxes: 2.4 e- bare mux noise (30 K, Fowler 8); ~6-7 e- for SCA. 0.02 e-/s dark current, ~95% QE, 99.7% operability. Bare muxes & hybrids to be delivered to STScI & ARC soon.
  - 2 k x 2 k **SB-290** & **SB-304** muxes fabricated & screened. Design features (incl. ref pixels) verified; yields adequate. UR evaluation to start soon. Expect same sensitivity as for 1 k x 1 k
  - Broadband AR coating produced & tested (incl. LN_2 cycling).
  - Packages for 4 k x 4 k module: parts fabricated; will be assembled soon.


2 k x 2 k & 1 k x 1 k Readouts


2 k x 2 k Module



Bare-mux noise of ~2.4 e- rms, 30 K, Fowler 8 (UR data)


4 k x 4 k Flight-like Package (contains 4 modules)

Tech Development Status: Si:As
Raytheon Infrared Operations, contract / tests via ARC

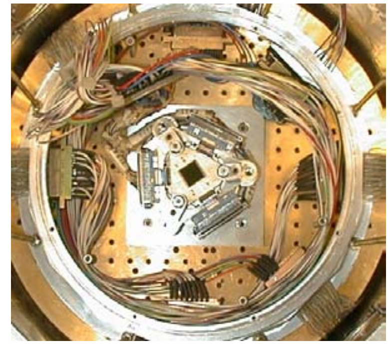
- Full-size MIRI prototype Si:As produced
- Shown to have comparable sensitivity to SIRTF IRAC arrays after 16x scale up. Dark current ~0.02 e-/s @ 6 K.
- Follow-on development contract, in coordination w/ JPL.

  Two full iterations funded; 20 month duration.

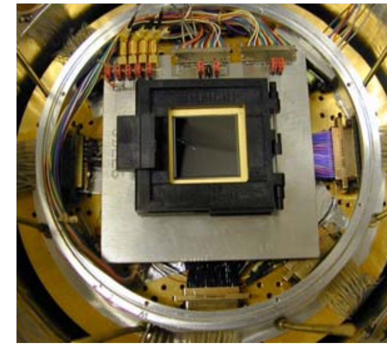
  Improved cryo-CMOS readouts (SB-291; ref pixels) in fab (Supertex)

  Improved Si:As detectors (enhanced short-wave response) in fab

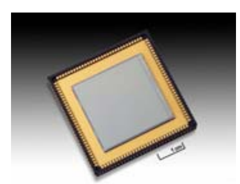
  Lab tests & proton tests upon delivery (3/03)



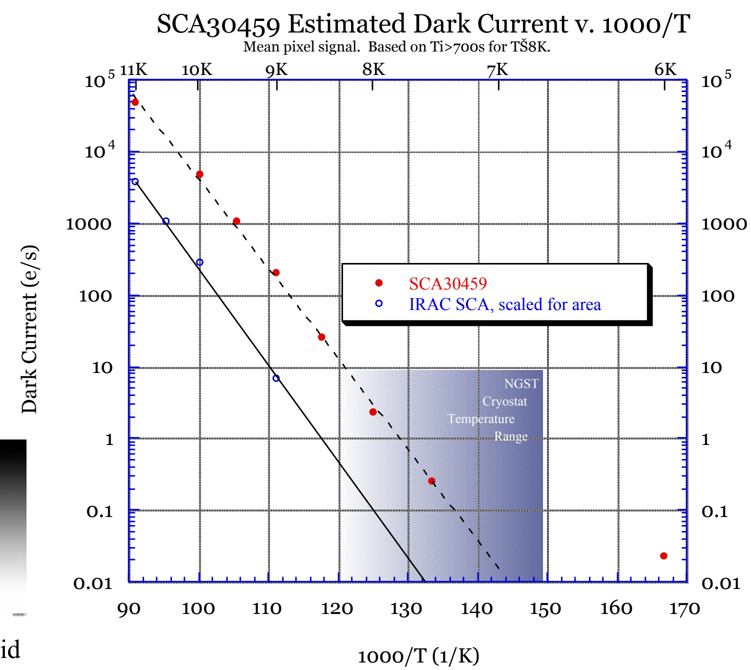
256 x 256 (SIRTF/IRAC)
12/98



1024 x 1024 (JWST)
3/01

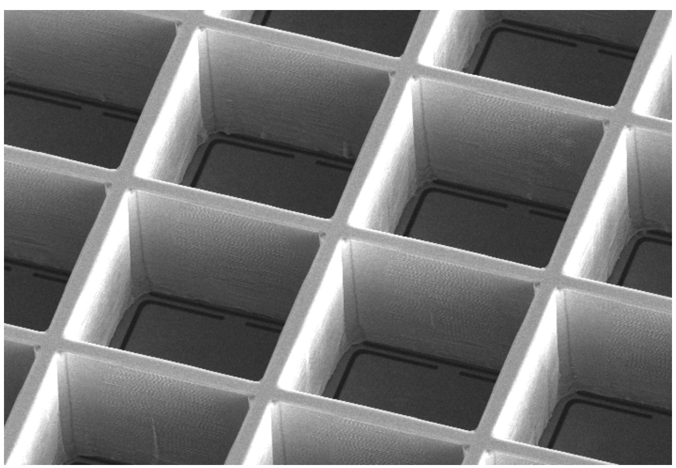


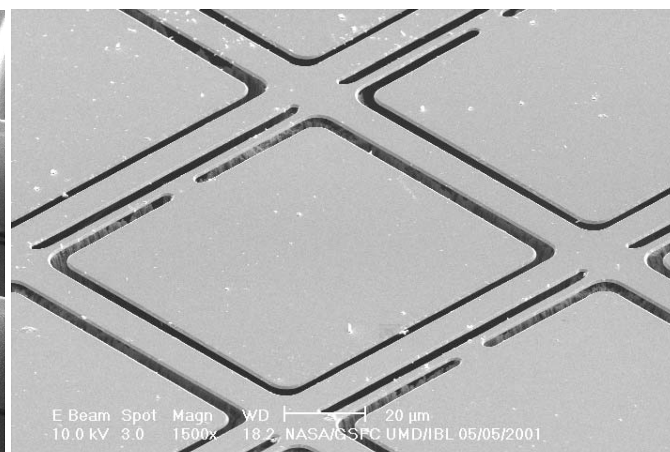
1024 x 1024 hybrid / SB-291 mux

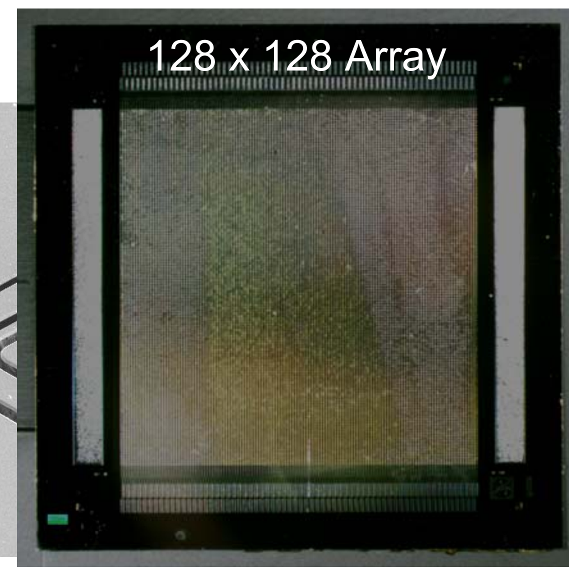


NIRSpec Programmable Aperture Mask

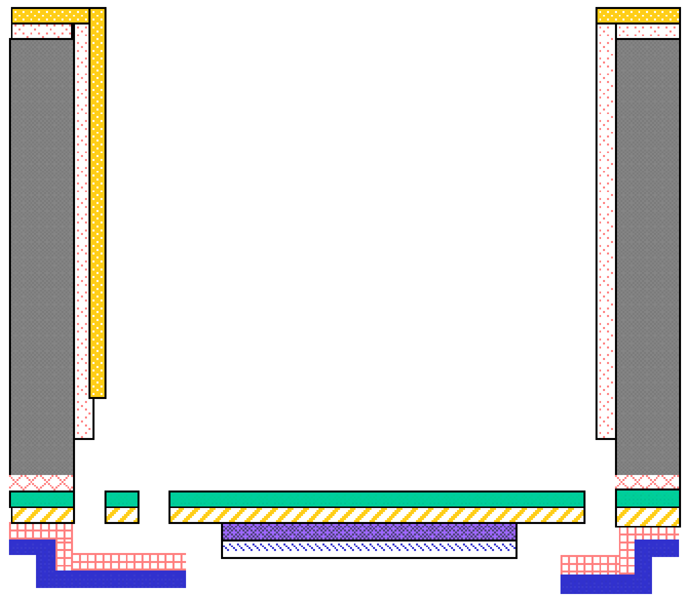
- Format - 1800 x 900 elements, Cell Size - 100μm x 200μm
- Operating Temperature - 30 - 35 K
- Efficiency and Blocking
  - > 0.70 when open, < 0.00035 when closed
- Reliability - ~10^6 cycles
- Power - 35 mW average dissipation

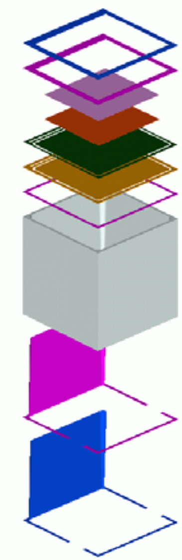






Cross Section of Unit Cell





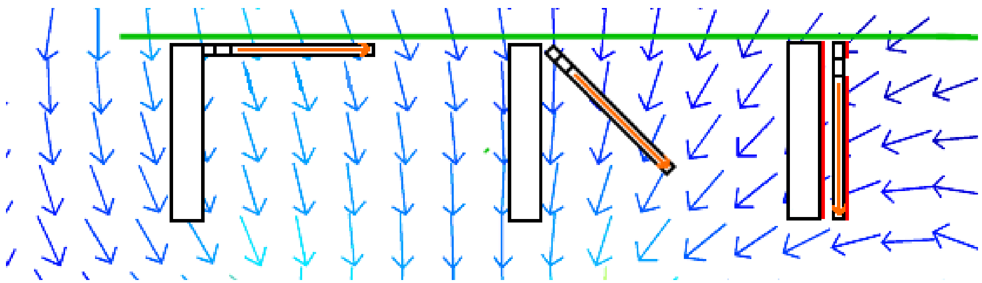
Exploded View

- Light Shield: Aluminum
- Support Grid: Silicon
- Etch Stop: Silicon Dioxide
- Interconnect/Shutter Electrode: Gold
- Light Shield Insulator: Silicon Dioxide
- Magnetic Pad: CoFe
- Shutter Mechanical Layer: Silicon Nitride
- Vertical Electrode: Gold
- Vertical Electrode Insulator: Aluminum Oxide
- Magnetic Pad Passivation: Aluminum

Micro-shutter Magnetic Actuation

External magnetic field moves shutter open

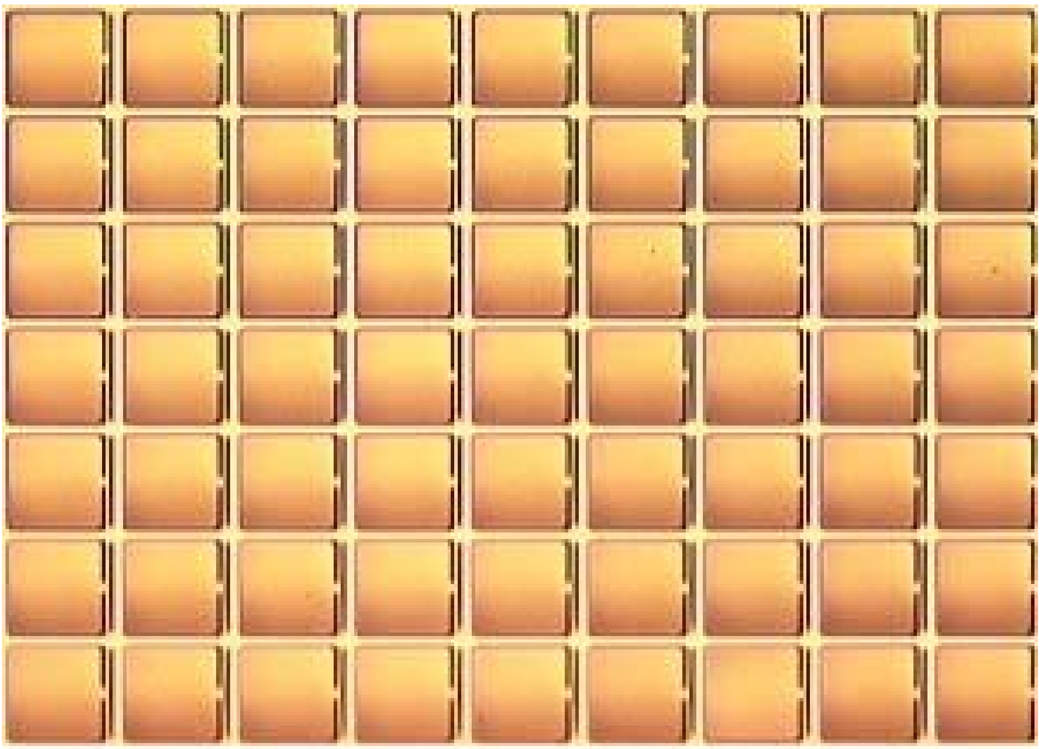
Shutter is moved down
as it is moved through magnetic field



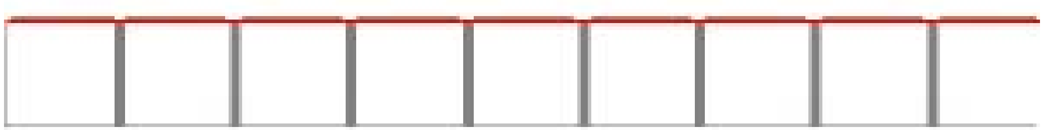
Magnetic metal on shutter
is magnetized

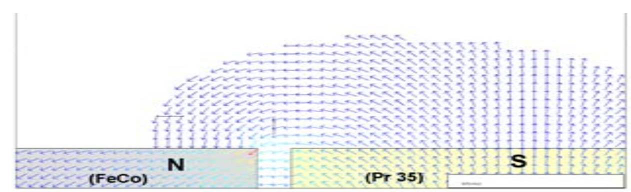
Shutter is electrostatically captured
and held in vertical position

All aspects of magnetic actuation and hold have been demonstrated



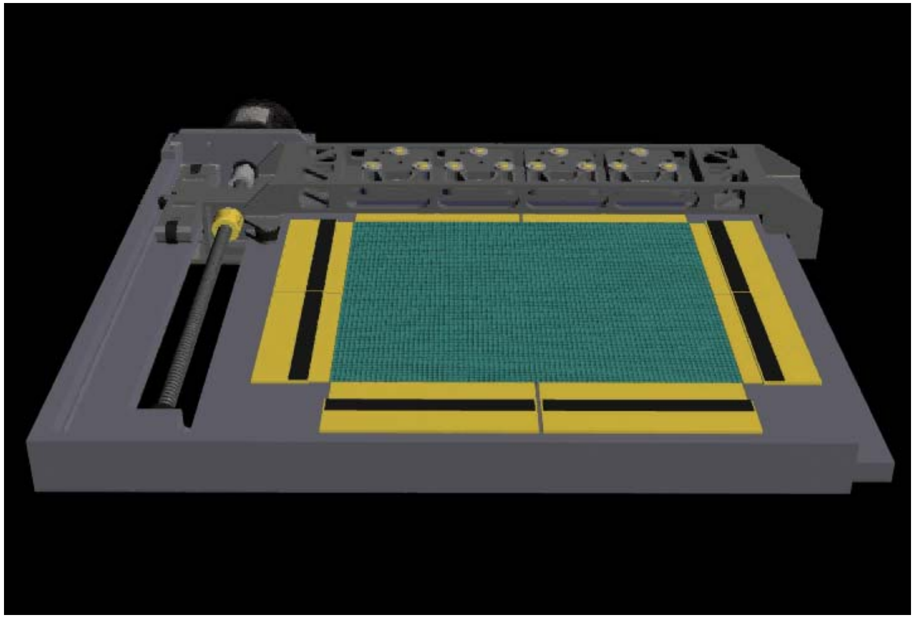
Microscope images were made with shutter edges in focus

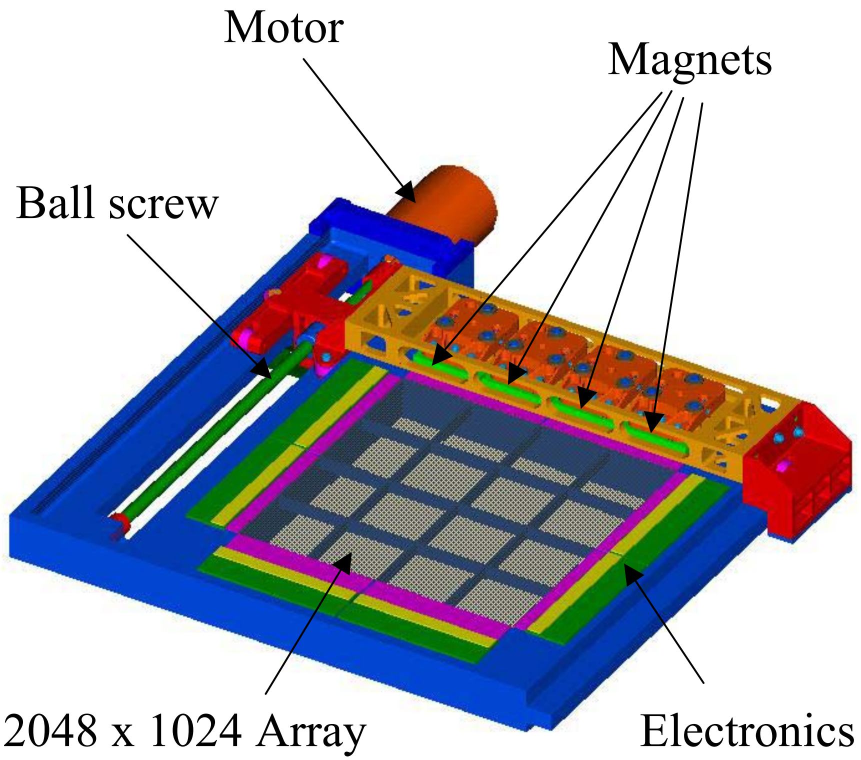




Shutter Mask Assembly Conceptual Design

- Mechanism translates magnet over array
- Four individually aligned permanent magnets provide field
- Drive electronics surround array





The Road Ahead

Decision Making In Progress

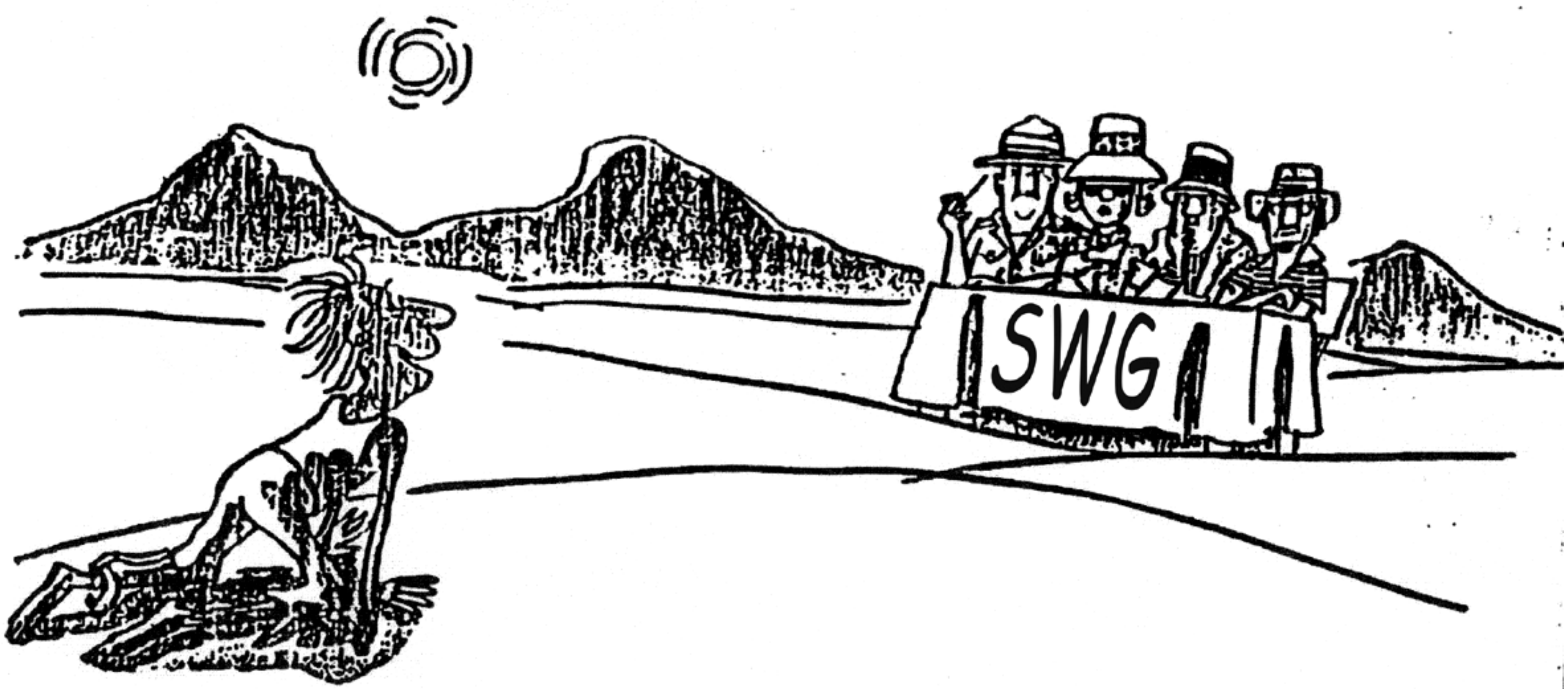
- **Phase B**
  - ✓ Acquire the JWST scientific investigations & select SWG
  - – Procure science instruments and FGS
    - ✓ NIRCam contract in place
  - – Procure long lead components
    - • flight detectors
    - ✓ NIRSPEC MEMS aperture mask
  - – Complete requirements and interface definition
  - – Complete detailed design and make/buy decisions
  - – Produce bread board and ETU systems

No Changes Beyond This Point

- **Phase C/D**
  - – Design, build, integrate, and test flight and GSE systems
  - – Receive SI's and integrate, test, and qualify the ISIM
  - – Deliver ISIM to prime contractor and support observatory I&T through launch
  - – Support on orbit verification

Summary

- **Extensive Phase 1 activity leaves the ISIM Project well positioned for the start of Phase 2**
  - Top level science requirements in place (ASWG, ISWG)
  - All instrument teams formed and working (NIRCam, NIRSpec, MIRI, FGS)
  - Implementation team and management organization for in house work in place
    - Project Manager: Bob Smith, Shared Services Manager: Tom Venator
    - Chief Systems Engineer: Matt Jurotich
    - ~ 50 engineers, scientists, and support staff at this point
  - Systems engineering development:
    - Level 2 requirements, instrument IRDs, ISIM/OTE IRD, budget allocations and tracking developed to appropriate level
    - Level 3 requirements development well underway
  - Integrated schedule and PERT network, GSE definition developed to appropriate level
  - Risk management plan under development
- **ISIM technology development program in place, running smoothly, and on track to meet TRL 6 by NAR requirement.**
- **Long lead procurements on track**



Thank god. A panel of experts!